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ABSTRACT

This report describes two interactive television systems built at Stanford University using funds from an equipment grant. Both employ digital systems to provide a method for students to respond to a question from an instructor or a computer. In the Interactive Classroom System, each student has a switch that he or she can set to any one of ten positions. The Individualized Instruction System provides each student with an alphanumeric keyboard, a color television set, and a single-frame memory. Both systems are intended to provide "testbeds" that can be used by faculty and students to develop new instructional techniques to make effective use of these forms of digital response technology.
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SE 029 104

FINAL REPORT
Creation of a Testbed for Innovative
Educational TV Experiments

by

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and W. R. Kincheloe

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PROGRAM IN INFORMATION TECHNOLOGY AND TELECOMMUNICATIONS

CENTER FOR INTERDISCIPLINARY RESEARCH

Stanford University

Stanford, California 94305

ABSTRACT

This report describes two interactive television systems built at Stanford University using funds from an equipment grant. Both systems employ digital systems to provide a method for students to respond to a question from an instructor or a computer. In the first system, the Interactive Classroom System, each student has a 10-position switch that he can set to any one of the ten positions as desired. A simple computer counts the number of switches set to each position, and provision is made to generate a histogram display from this data. This system is installed in a TV classroom in which every two students share a TV monitor. The histogram can be viewed as an inset on the TV screens of the student TV monitors along with some other picture or as a single TV picture. This system allows students to respond to a question from the instructor and to see their collective response immediately. All students see the same picture on their TV screens in this system. A total of 72 voting students with 10-position switches can participate, using two adjoining rooms. Non-voting students can also view the TV screen for this class at a number of remote locations.

The second system, the Individualized Instruction System, provides each student with his own alphanumeric keyboard, a color TV set, and a single frame memory. Only a pilot system of this type has been assembled with three remote installations. A wide range of analog and digital images can be created. The system can be operated in conjunction with the large computers at the Stanford Center for Information Processing.

Both systems are intended to provide testbeds that can be used by faculty and students to develop new instructional techniques that will

make effective use of these forms of digital response technology. This type of system capability is expected to become widely available through two-way cable television systems during the coming decade, and the objective of these testbeds is to gain experience with this technology, in order to facilitate the development of instructional services using two-way cable in the future.

TABLE OF CONTENTS

	<u>Page</u>
I. INTRODUCTION	1
II. THE INTERACTIVE TELEVISION CLASSROOM SYSTEM	3
III. THE INDIVIDUALIZED INSTRUCTION SYSTEM	17
A. The Head End Facility	19
1. Head End Computer	19
2. Image Generation Facilities	24
3. Test and Video Monitor Equipment	32
4. Interconnection and Transmission Facilities	32
B. Remote Student Facilities	34
C. Experimental Configurations	36
IV. CONCLUSIONS	39
ACKNOWLEDGMENT	40
REFERENCES	41
APPENDIX	42

LIST OF ILLUSTRATIONS

<u>Figure</u>		<u>Page</u>
1	Block diagram of the Interactive Television Classroom System	4
2	Photographs of the Interactive Television Classroom.	6-7
3	Histogram display equipment and displays	9-12
4	Split screen equipment and displays to allow histogram to be combined with other images on TV screen .	13-14
5	Front camera equipment used to view student speaker during a class discussion	15
6	Block diagram of individualized instruction system .	18
7	Block diagram of head end facility for individualized instruction system	20
8	Photograph of head end equipment	21
9	Block diagram of central control computer subsystem.	22
10	Block diagram of RAMTEK digitally-controlled image generator subsystem	25
11	Color video images produced by RAMTEK subsystem . .	27-28
12	Student equipment configuration block diagram . . .	35

I. INTRODUCTION

Cable television systems with limited two-way interactive capability are expected to become widely available during the coming decade. Each user in such a system will probably have a twelve button response pad similar to a Touch-Tone[®] telephone pad which he will be able to use to transmit digital signals upstream to a computer at the cable system central studio or head end. Full alphanumeric keyboards may be available as an extra-cost option. Future educational uses of such digital response systems depend on the development of suitable educational software and on the understanding by educators of this new technology [1]. This project was an equipment grant designed to provide a hardware capability at Stanford University to perform educational experiments with a two-way medium of this type.

Two separate hardware units were purchased and assembled, corresponding to the two basic types of interactive systems that are possible. In the simplest type of system (referred to here as the Interactive Classroom System) all users see the same television picture, but individual digital data responses can be sent by individual users to a computer at the head end of the cable system and all or a portion of the television screen can be used to display a tally of the users' responses. In the more complex type of system (referred to here as the Individualized Instruction System) each user can not only transmit individual responses but also be sent individual messages on his television screen, so that individual users can each be looking at different pictures on their screens at the same time.

The system of the simple type that we purchased is an in-class digital response system using a very simple hardware configuration developed

by T. B. Sheridan at MIT [2]. In this system each student has a 10-position switch at his desk in one of the Stanford television classrooms. A small "computer" calculates how many students have their switches set to a given number and prepares a histogram display which can be shown to the students and their instructor on TV monitors in the classroom. Remote TV students also see the display, but cannot vote in the present system. This system is similar in function to students raising their hands, but allows ten positions rather than two. It provides a rapid, simple communication medium for in-class use which could be extended to large classes in which the students are in homes or offices and are all viewing the instructor and responding via a cable television network.

The other unit is intended for individualized use and is similar in design and function to the Mitre Corp. TICCIT system [3]. Conventional TV sets are supplemented by alphanumeric keyboards and by local single-frame memories to provide a form of computer terminal suitable for use in cable television systems. This system is intended to be used with CAI and library-type software like the Stanford SPIRES system. It can be connected to the Stanford Center for Information Processing, and by means of a connection to the ARPA network, to many other large computing centers.

II. THE INTERACTIVE TELEVISION CLASSROOM SYSTEM

The Interactive Classroom System is a system in which students can make limited digital responses to the instructor in a classroom environment. Each student has a switch that he can set to any of ten positions. A small computer counts the number of switches set to each position, and provision can be made to display the tally on a gas tube digital display next to the instructor or a histogram display on the television screen. This system using the gas tube display could be used in a classroom in which television is not used at all. However, it was installed in a television classroom of the Stanford Instructional Television Network (SITN), in order to test applications that could be extended to situations in which all or a portion of the class members are at remote locations and only able to respond through cable television or some other closed circuit TV system, such as the SITN microwave broadcast system [4] that uses frequencies in the Instructional Television Fixed Service (ITFS) band [5]. The histogram display in the present system can be viewed by users at remote locations, but only users in the television classroom and an adjoining overflow classroom have switches. Thus, this system is one in which all students see the same picture on their television sets, but students can, through changes in the positions of their switches, cause changes in the histogram display that they all see.

Figure 1 is a block diagram of the system. Seventy-two 10-position switches are mounted on the student desks in a TV classroom. The Sheridan vote counter, obtained through Prof. Thomas B. Sheridan at MIT, counts the number of switches turned to each position and provides output signals proportional to the number of switches in each position. The output signals

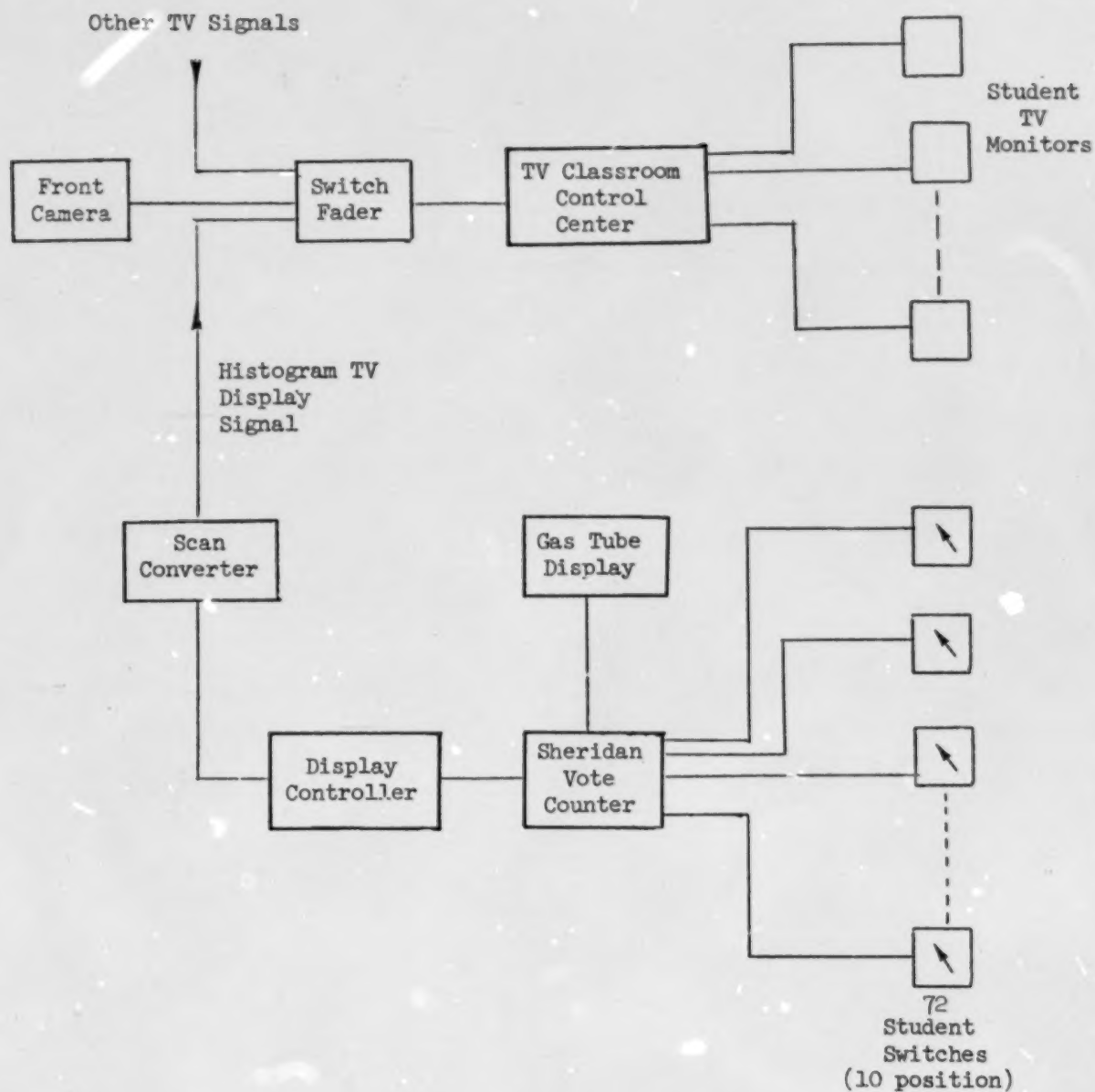


Fig. 1. Block diagram of the Interactive Television Classroom System.

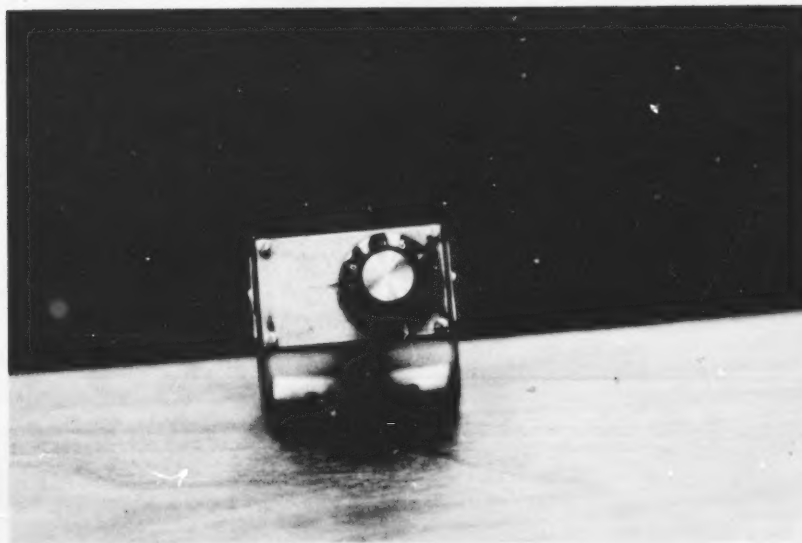
can be used to drive an optional gas tube display unit which can be arranged to be seen by the class. This display produces numbers sequentially in time corresponding to the number of switches in each position. In order to provide a more quickly understood picture of the distribution of switches set to each number, a histogram display can be produced by the display controller. The output of the display controller is fed into a scan converter that converts the signal into a standard TV format and provides a TV signal which displays the histogram. This signal is fed into a switch fader that allows the histogram display to be shown on the student TV monitors in a split screen format along with another TV picture, such as the picture of the instructor.

Since the interactive television classroom system is intended to facilitate interaction between the students and the instructor, it is often important to be able to show a picture of a student on the screen, as well as the instructor. Therefore, this classroom was fitted with a front camera, also shown in Fig. 1, and its signal can be combined with a picture of the instructor, a view of the instructor's desk top showing drawings or equations, or the histogram display, using the switch fader. Provision has also been made to make videorecordings of this system in operation, by simply recording the TV display during the course of a class.

Figure 2a is a photograph of student desks in a TV classroom. On each desk a TV monitor is mounted, along with two 10-position switches. Two students share the TV monitor, but each student has his own switch. Figure 2b is a closeup of a switch. Figure 2c is the instructor's chair, TV monitor, and the Sheridan vote counter with the gas tube display unit on top of it. Figure 2d is a closeup of the vote counter and gas tube



a. Student desks with TV monitors and switches.

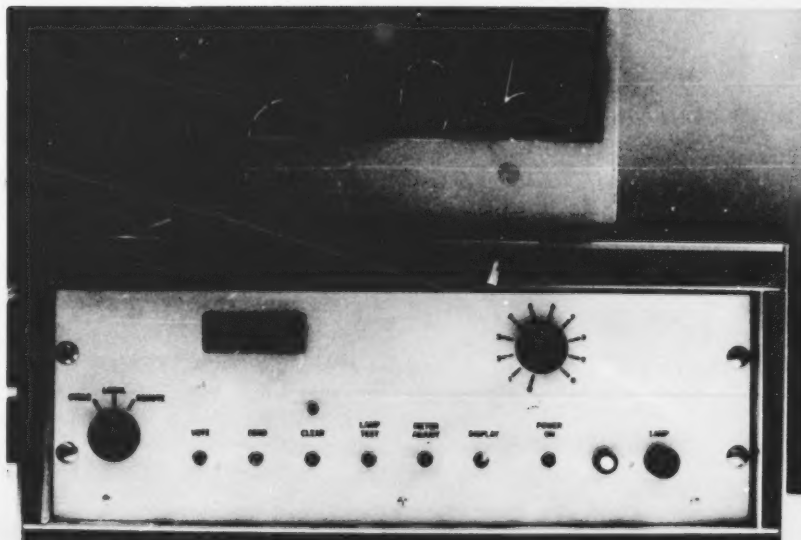


b. Switch closeup.

Fig. 2. Photographs of the Interactive Television Classroom.



c. Instructor's desk with monitor and Sheridan vote counter.



d. Sheridan vote counter and gas tube display unit.

Fig. 2. Photographs of the Interactive Television Classroom.

display showing that 5 students have their switches turned to position 2.

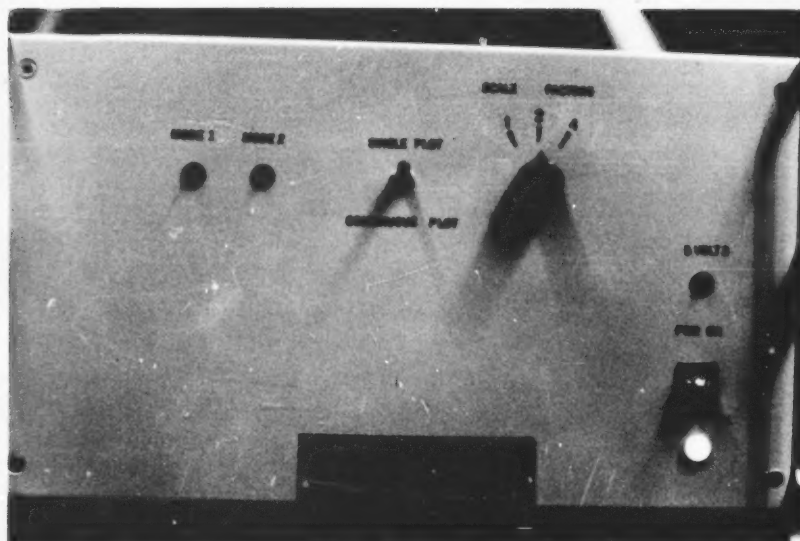
Figure 3a is a photograph of the display controller for the histogram display. Figure 3b is the scan converter. Figure 3c is a TV display of a histogram for a case where all of the 72 switches are set to one of the four positions 0, 1, 2, 3. Figure 3d is the same case but for an expanded scale setting in which the size of each bar of the histogram has been multiplied $\times 2$. Figure 3e is the same case $\times 4$. Figure 3f is a case with the switches distributed over all ten positions; the scale control is on the $\times 2$ setting. Figure 3g is for all switches set to the same position; the scale control is on the $\times 1$ setting.

Figure 4a is a photograph of the switch fader used to create split screen images. Figures 4b and 4c show two uses of the fader, one with the instructor's face as a small inset, the other with the instructor and a student in a split screen format.

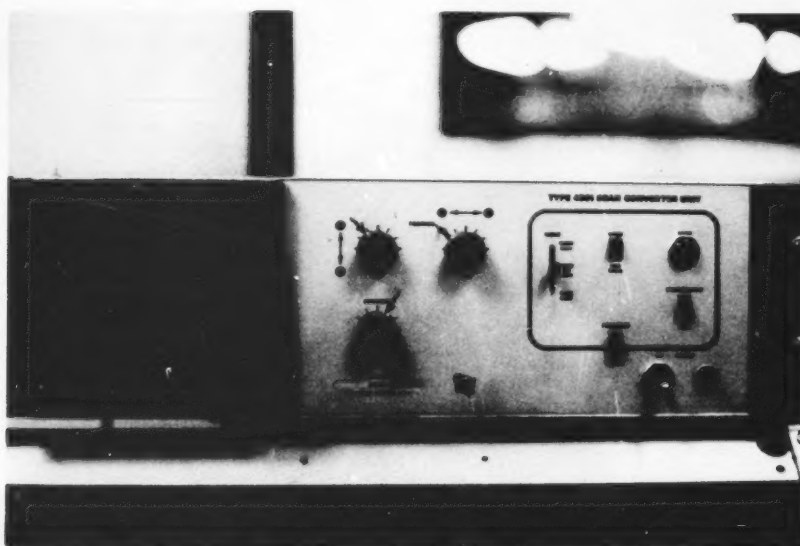
Figure 5a is the front camera and Fig. 5b is the front camera controller. The student in the right half of Fig. 4c was viewed from the front camera.

The objective of this system is to create a testbed, in a classroom setting, in which students can respond to the instructor by means of a digital response signaled from their position switches. The number of students signaling each number is made visible to all students in the classroom on their TV monitors in an easily comprehended histogram display.

Switches are provided in the main classroom, with the instructor, and also in an adjoining overflow classroom in which the instructor and the students in the main classroom can be made visible on television monitors. Students in the overflow classroom, like students in remote locations throughout the network are also supplied with microphones that allow them

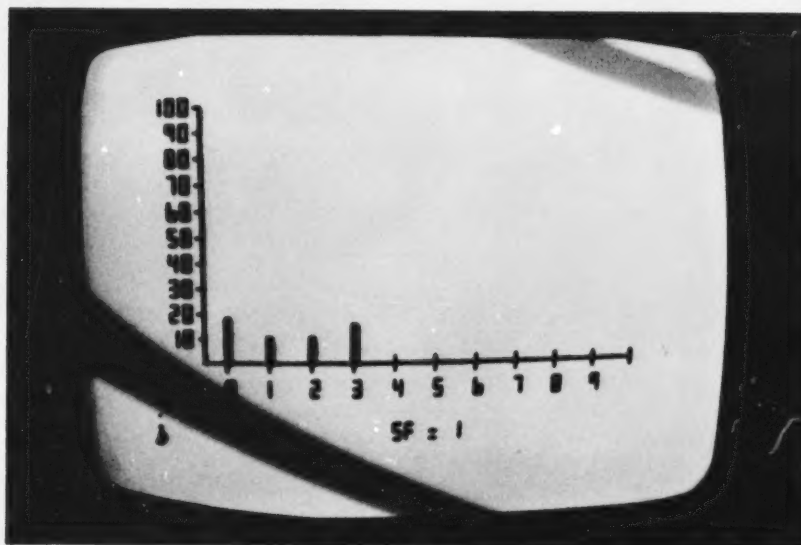


a. Display controller.

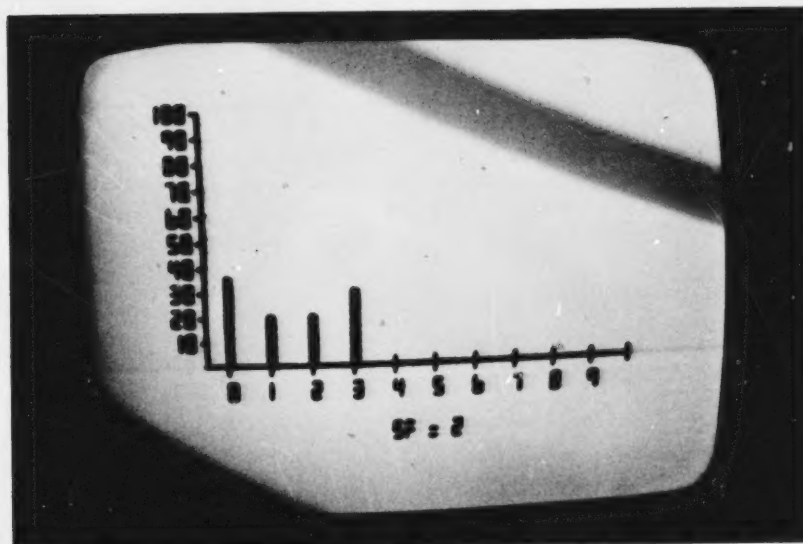


b. Scan converter..

Fig. 3. Histogram display equipment and displays.

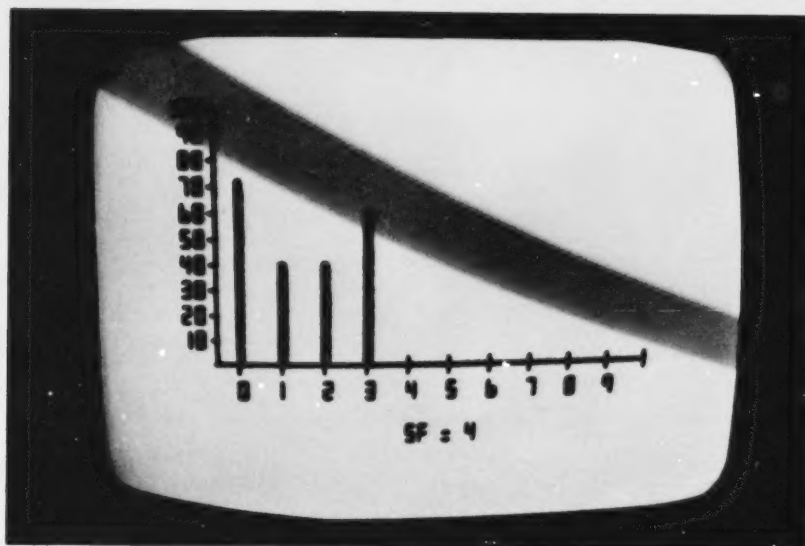


c. Typical histogram display for controller on x1 setting.

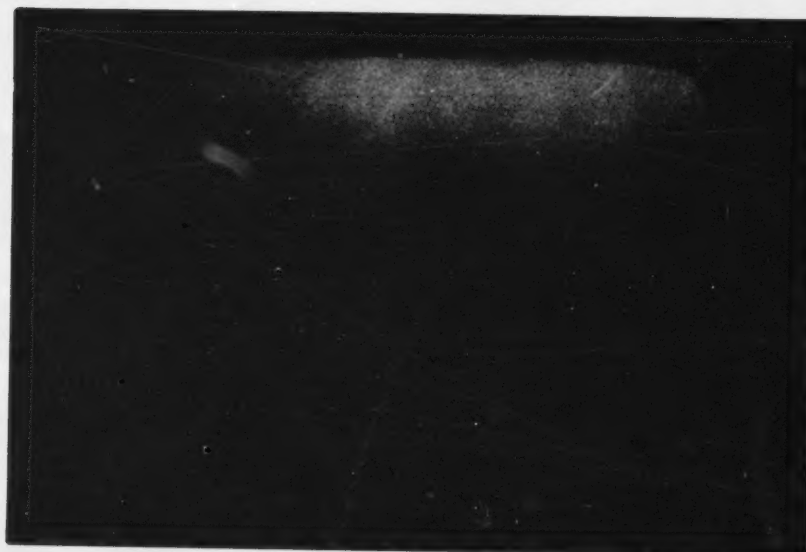


d. Display for same vote count as c, but controller on x2 setting.

Fig. 3. Histogram display equipment and displays.

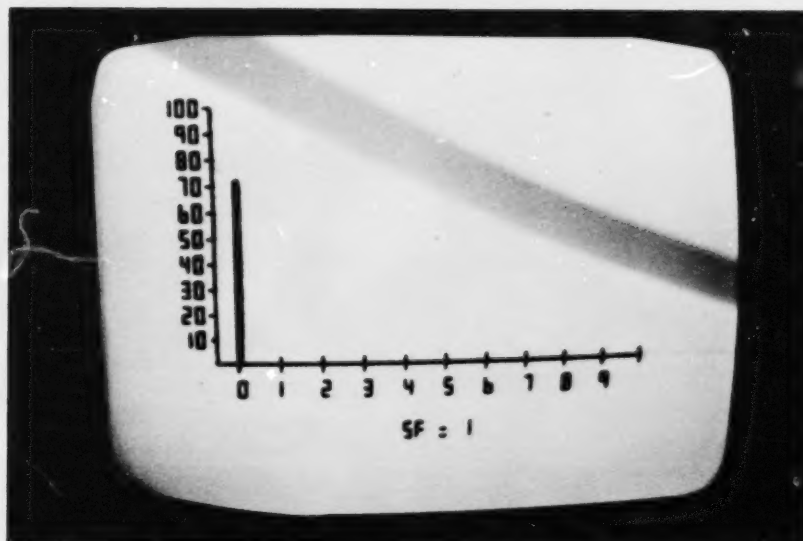


e. Display for same vote count as c and d, but controller on $\times 4$ setting.



f. Display for a vote with nonzero votes on all ten positions, $\times 2$ setting.

Fig. 3. Histogram display equipment and displays.

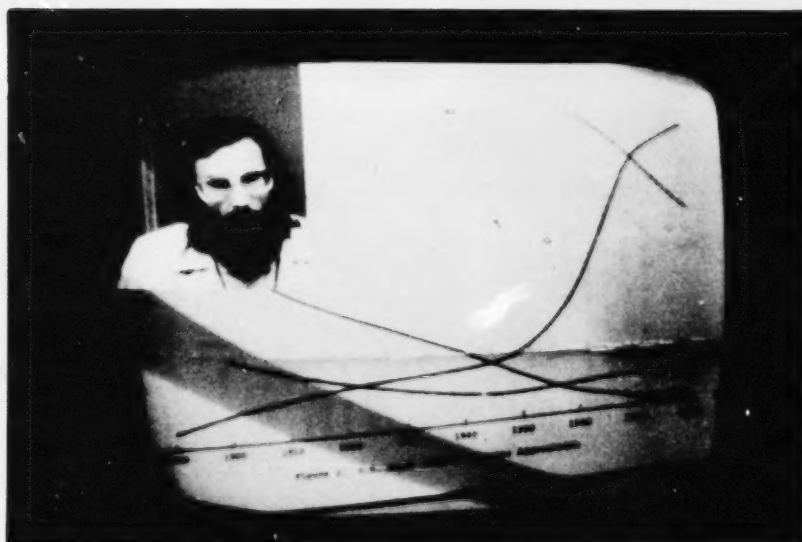


g. Display for a unanimous vote, xl setting.

Fig. 3. Histogram display equipment and displays.



a. Switch fader.



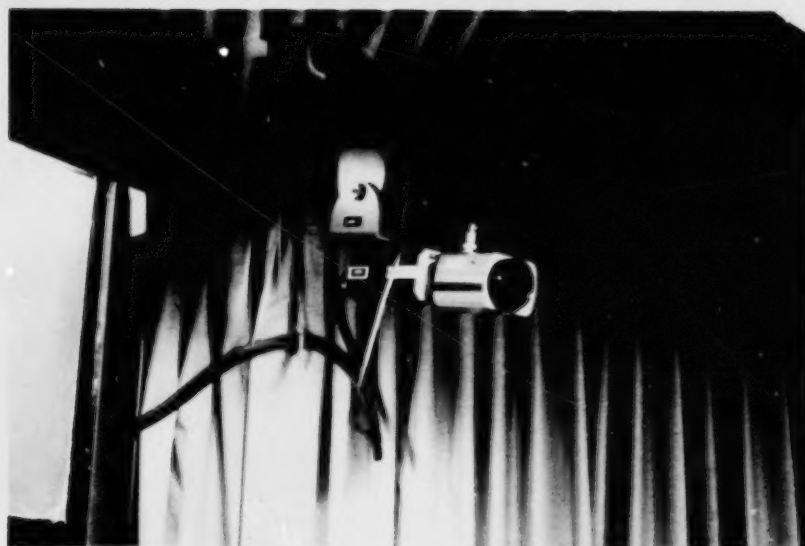
b. Display with fader set to provide two unequal images.

Fig. 4. Split screen equipment and displays to allow histogram to be combined with other images on TV screen.

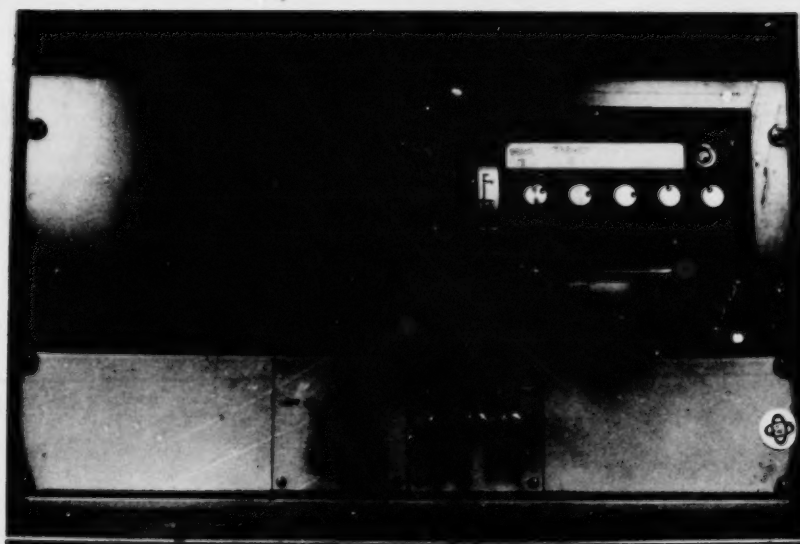


c. Display with fader set to provide two equal images.

Fig. 4. Split screen equipment and displays to allow histogram to be combined with other images on TV screen.



a. Front camera.



b. Front camera controller.

Fig. 5. Front camera equipment used to view student speaker during a class discussion.

to participate in the class discussions and to ask questions. Thus three "populations" of students with different communication capabilities can be included in any experiment; those in the main classroom with face-to-face contact with the instructor as well as the digital response capability, those in the overflow room with digital response and voice and television contact, and those in remote locations with voice and television contact only, who see the results of the in-class student votes on television but who cannot vote themselves.

Two kinds of experimental classroom teaching using the system are envisioned. In the first, the digital response capability would be used to give the student a feeling of participation by asking him questions with "correct" answers. The student would select a response from a set of possible responses, and he would receive immediate feedback from the instructor as to the correct answer. The instructor and the class would also see how well the class was doing, and the instructor could alter his presentation to adapt to a class with a predominance of "incorrect" responses. To make use of this teaching format, an instructor would have to reorganize his presentation, but the basic content would not have to be much different from that of many existing classes, especially in engineering and the physical sciences.

The other type of teaching technique in which a digital response capability could be of interest is one in which class participation is sought, and no "correct" answer exists [6], [7]. This system allows the instructor to pose questions and ask students to commit themselves to a position anonymously before the discussion begins. Then the instructor can ask a student with a minority position to defend his position. By this and similar techniques, the digital response capability can be used to encourage discussion in classes in which this type of discussion is sought.

III. THE INDIVIDUALIZED INSTRUCTION SYSTEM

The Individualized Instruction System is a system in which each student has a computer terminal connected to a central computer, as would be the situation if students were learning in their homes through a cable TV system. Several degrees of student interaction are possible, ranging from simple one-digit student response up to the most complex terminal option which would include both an alphanumeric keyboard and a frame-grabber unit in conjunction with a standard TV set which would allow individual student interaction with a computer for computer-assisted instruction. The system is intended to be compatible with a standard cable television distribution system, either one- or two-way, providing capability for addressing analog or digitally generated images to and recognizing multi-character messages from remote students on a time-sharing basis.

The basic system configuration is shown in Fig. 6. It consists of a small computer for system control, capabilities for generation and transmission of both analog images and digital images of text and/or graphics under computer control to the remote student locations, and means for user response feedback. Provision is made for up to three remote interactive student installations. Cables have been installed from the central equipment location to the Stanford Instructional Television Network Master Control, from which cables to other campus locations are available. Upstream communication from the remote student to the control computer is accomplished by telephone line or separate cable.

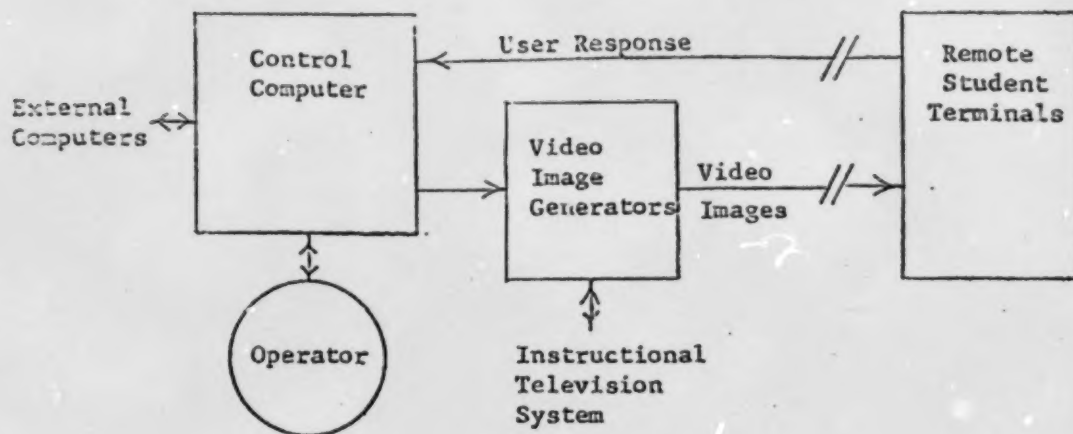


Fig. 6. Block diagram of individualized instruction system.

A. The Head End Facility

The functional configuration of the head end facility to be used for generation and transmission of educational material to the remote student locations is shown in the block diagram of Fig. 7. A small computer receives commands, both from the local operator and the remote students, controls the generation and transmission of analog and digital images, provides access to external computing resources (particularly the Stanford Center for Information Processing), and in general allows flexible changes in system operation under software control. A variety of television images, both analog and digital, are generated under computer control for transmission via video or R-F modulation on TV channels over broadband cables to remote student locations. A video patch panel allows flexible interconnection of video sources, head end monitor and test equipment, modulators and broadband cables to the Stanford Instructional Television Network. Figure 8 shows a photograph of equipment located in the head end facility.

1. Head End Computer

The purpose of the head end computer is to accept commands from both the system operator and remote students for the generation and transmission of video images to various users. It provides a means for interaction with external computers. In an operational mode it will gather and process data for evaluation of system operation. It provides great flexibility in system configuration and operation by software modification.

Components of the system control computer are shown in the block diagram of Fig. 9. The central processing unit is a NOVA 2/10 minicomputer with 16,384 word, 16 bit core memory and real time clock. Expanded memory capacity is provided by a 1.25 Megaword cartridge disc system consisting

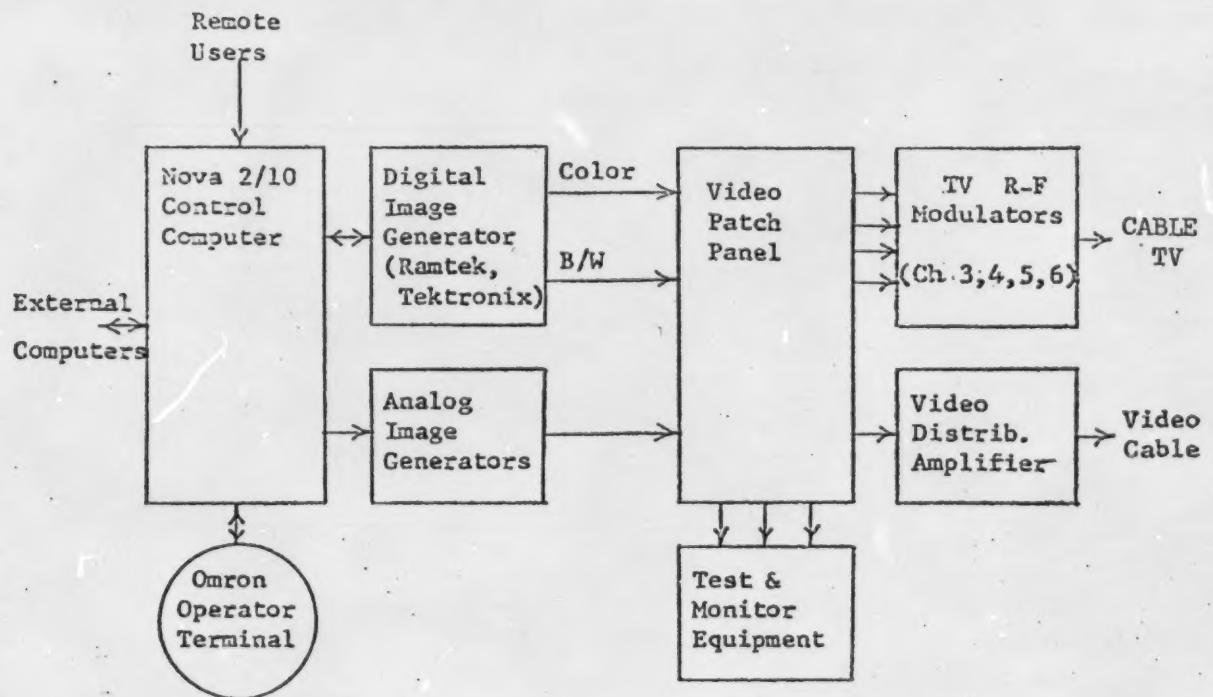


Fig. 7. Block diagram of head end facility for individualized instruction system.

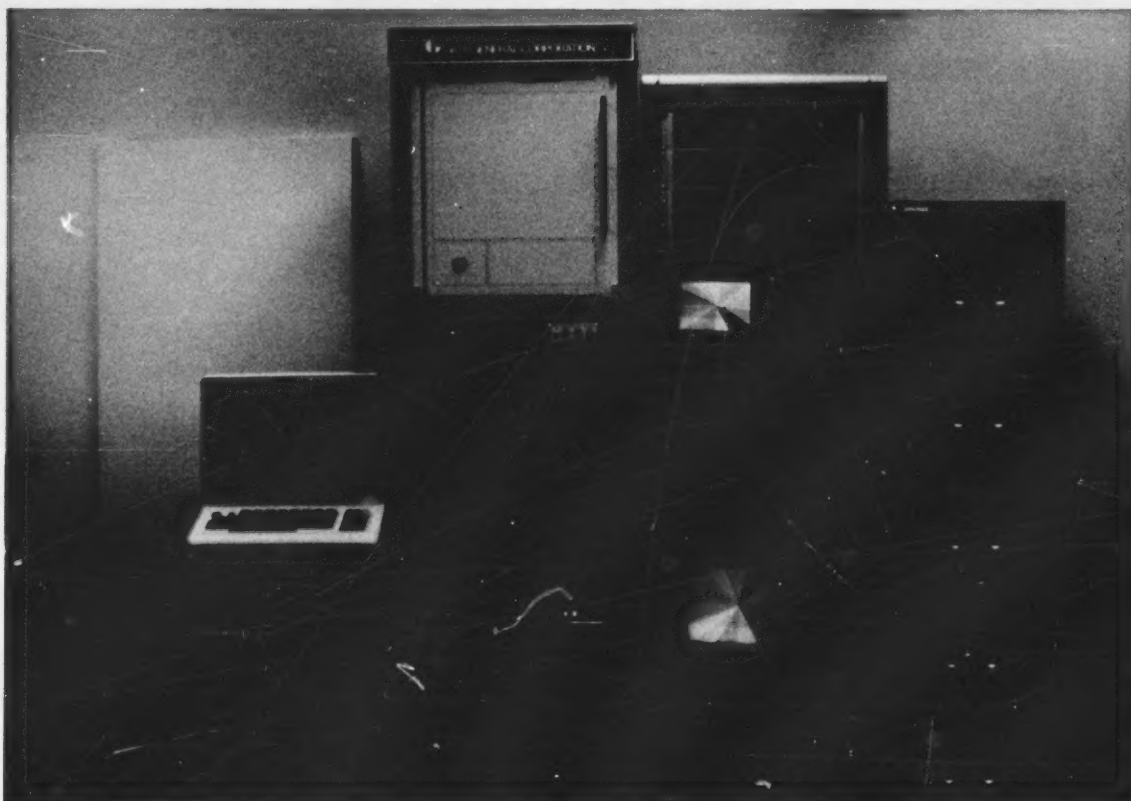


Fig. 8. Photograph of head end equipment.

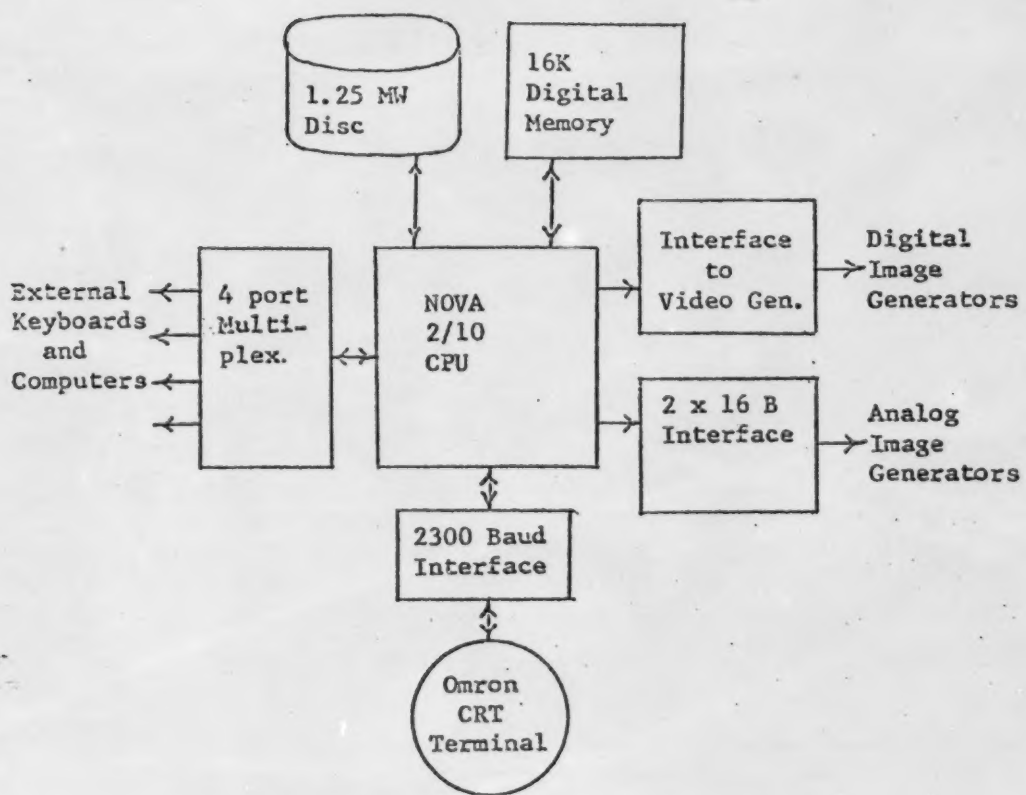


Fig. 9. Block diagram of central control computer subsystem.

of a Disc Control Unit, Disc Drive, Disc Cartridge and Power Supply. Several interface units provide flexibility for interconnection with external systems and equipment: a 2300 baud interface to an Omron visual terminal permits local input of text and control commands by the system operator; two interfaces are supplied, both for digital image generation (graphic and text, including color) and for control of analog image generation equipment (such as the storage tube scan converter or camera control for reproduction and transmission of images derived from microforms or other sources). Finally, a four-port multiplex interface permits interaction by way of telephone and direct lines to external digital computers, in particular the Stanford Center for Information Processing (SCIP) IBM 360/67 and two local minicomputers, and to remote student keyboards.

The photograph of Fig. 8 shows the location of the head end computer components. At the far left is the Omron visual terminal for operator interaction with the computer. The left equipment rack holds the NOVA 2/10 CPU, below which is the cartridge disc system. Above the NOVA CPU is the RAMTEK video image generator, to be described in the next section.

The software for the Interactive Student System is based on the standard Data General Real-Time Disc and Operating System (RDOS). RDOS supports the use of a macro-assembler, an on-line text editor, relocating loader, and a symbolic debugger, as well as FORTRAN, ALGOL and BASIC compilers. Making use of the programming software, we have produced a real-time display management system which permits a user to write image generation programs in FORTRAN using specially programmed (in MACRO) subroutines to generate the appropriate instructions for execution by the RAMTEK video generation equipment. Interrupt level software manages

the transfer of image generation commands from the NOVA to the RAMTEK as fast as the RAMTEK will accept the data.

In addition to the display maintenance software, we have written modules which will permit the OMRON and user display/keyboard terminals to access computing facilities at Stanford's Center for Information Processing (SCIP). We expect to use this capability to test the remote use of SPIRES (Stanford Public Information Retrieval System), the WYLBUR text editor and remote job entry service, and the general use of the SCIP facilities for bulk data storage.

Suitable cabling is being installed also to connect the NOVA facility to a PDP-11/20 nearby which has access to ARPANET so that the feasibility of accessing ARPANET resources for on-line classroom display can be assessed. Software for this purpose has yet to be installed in the NOVA.

2. Image Generation Facilities

A prime function of the head end facility is the generation, under computer control, of images to be transmitted in television format over a cable system to the remote student locations. Both digital and analog image generation equipment is provided in the head end facility.

a. Digital image generation. The primary means for constructing images under direct computer control is provided by the RAMTEK system, shown in block diagram form in Fig. 10, and located physically above the NOVA Central Processing Unit in the left rack shown in Fig. 8. Associated with the RAMTEK image generating system are the Grass Valley Co. TV Sync Generator, 3.58 MHz Oscillator and Color Lock unit, and Color Background generated located in the Grass Valley Co. tray shown in the lower center of the right equipment rack of Fig. 8. Controls for background hue and

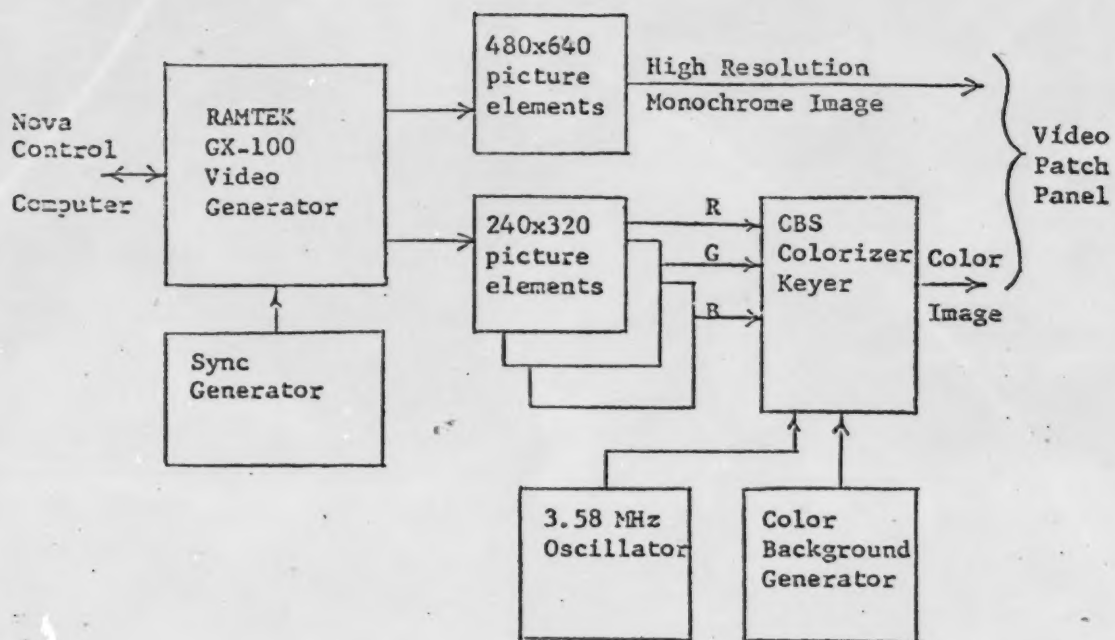


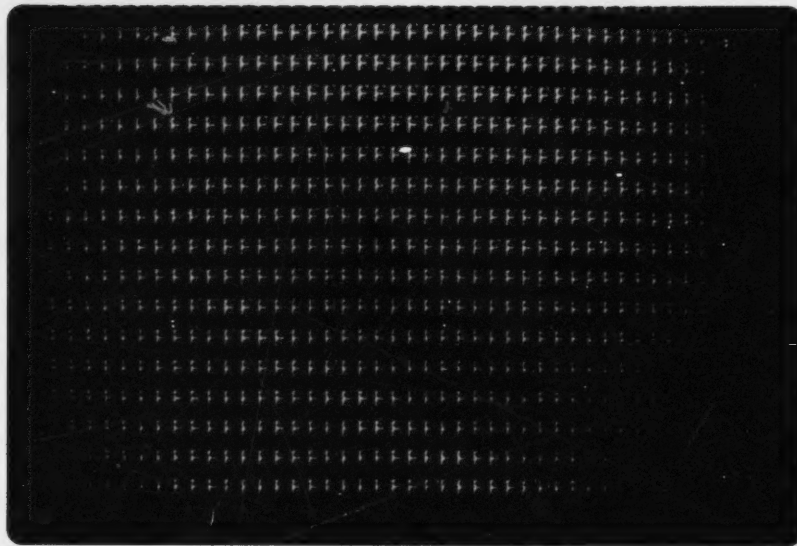
Fig. 10. Block diagram of RAMTEK digitally-controlled image generator subsystem.

intensity are located on the panel immediately below the RAMTEK unit in the upper left equipment rack in Fig. 8.

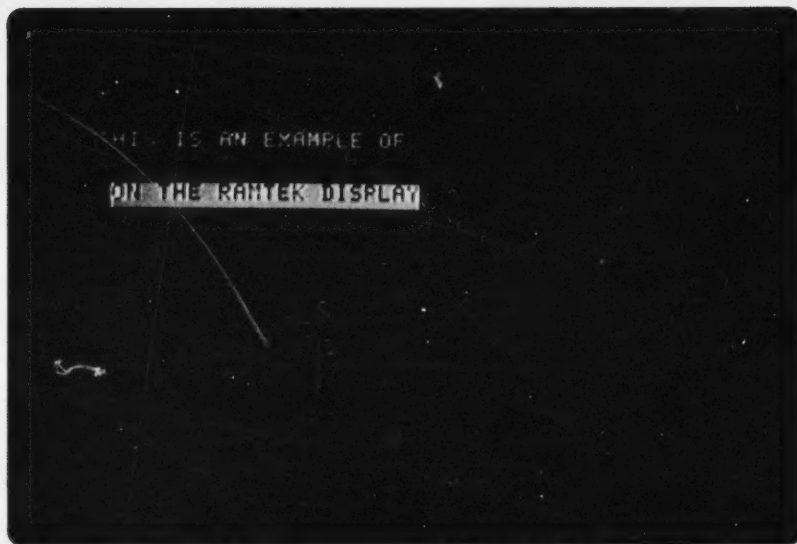
By allowing computer control of each picture element in the construction of a television video image, great flexibility is provided in the generation of a wide variety of both textual and graphic displays by software modification, including both color and high-resolution monochrome. As shown in Fig. 5, the RAMTEK is equipped with memory for three moderate resolution (240 lines, 320 elements per line) and one high resolution (480 lines, 640 elements per line) display outputs. The lower resolution channels may be used as three independent monochrome channels or as one color channel by using the CBS Colorizer Keyer with the three memory units providing the red, blue and green components. Fourteen unique colors plus grey background are available and may be used with the vector graphics capability and/or the included character generator. This part of the system is similar to and has somewhat more capability than the Mitre TICCIT interactive system. The capabilities may be expanded to permit experiments with TICCIT courseware available from Brigham Young University.

Examples of image generation with the RAMTEK system under software control are shown in Fig. 11. Figures 11a and 11b illustrate character generation, the latter demonstrating color variation with different words. (Actually, each character can be shown in a different color.) Figures 11c and 11d illustrate various hues that can be provided; the former showing a stationary color bar generator and the latter a rotating color wheel. A continuously variable color background is also provided.

In addition to the powerful digital image generation capability provided by the RAMTEK system (intended primarily for computer control by

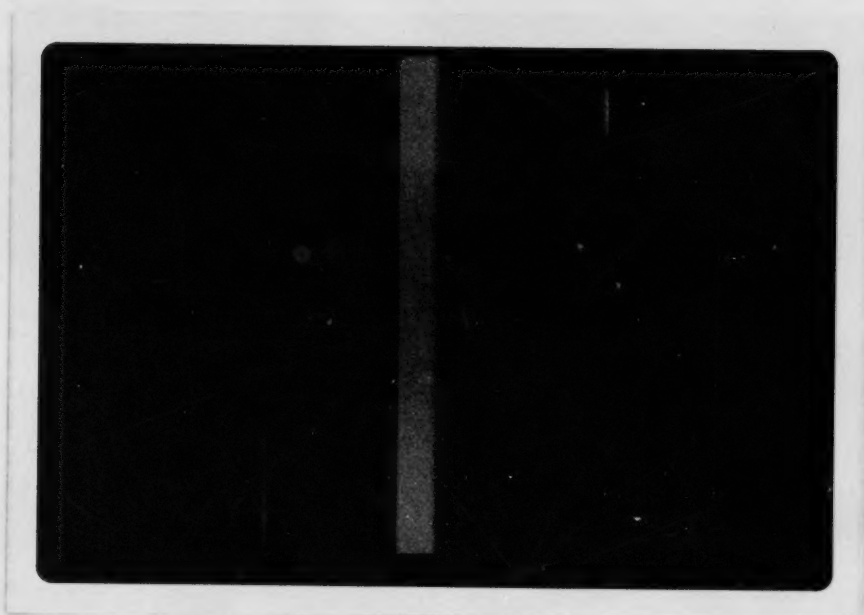


a. Digitally generated text.

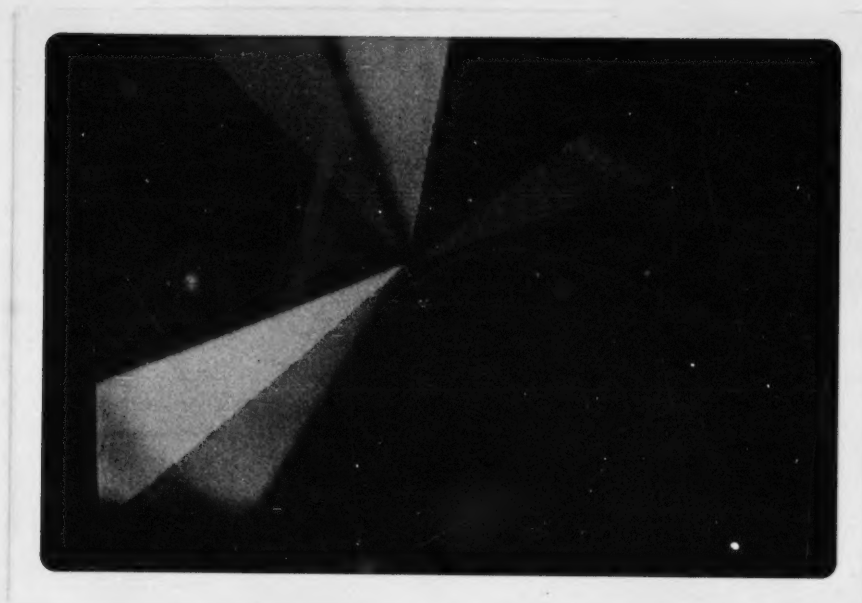


b. Color keyed text.

Fig. 11. Color video images produced by RAMTEK subsystem.



c. Color bars.



d. Rotating color wheel.

Fig. 11. Color video images produced by RAMTEK subsystem.

the NOVA or external computers), a second digital image generation capability is provided by the Tektronix 4501 scan converter, also acquired under this grant and available for experimentation. The Tektronix unit is primarily intended for display of student feedback in the television-equipped student classroom, as discussed in Section II, but it is also available for use as a part of the Individualized Instruction System. Under computer control, the Tektronix scan converter uses digital information to construct a stored image which is then available as an output in conventional monochrome television video format.

b. Analog image generation. In addition to digital image generation provided by the equipment described above, several methods of providing analog video images are available, also under control of the NOVA computer. The direct cables to the Stanford Instructional Television Network (SITN) Master Control room allow access to any of the SITN facilities; these include live television programming from any of the five studio classrooms, each of which is equipped with multiple cameras and video mixing equipment, as well as off-the-air live television and videotape and videocassette sources. Textual messages can be generated and/or superimposed on the video images by character generation equipment located in the SITN Master Control for general broadcast to all viewers.

For experimentation with individual remote students utilizing this system, several kinds of image processing can be provided. Individual television frames can be selected and selectively addressed to remote students using several types of analog frame-grabbing equipment. The Hughes Model 639-VHR silicon storage tube scan converter provides individual frame memory for up to 30 minutes with both high resolution and retention of gray scale, and with great flexibility in scan rates of

both writing and reading stored images. A Hitachi Memoryvision television includes a small video disc for storage of an individual television field. While the resolution is inferior to the Hughes scan converter (having only 252 lines and 3 MHz video bandwidth), it offers unlimited storage and viewing time and the promise of low-cost image storage with some modification to permit use with external monitors using interlaced scanning. A third frame-grabbing capability for analog image generation is provided by the Tektronix Model 4501 Scan Converter mentioned above as part of the Interactive Classroom System, but which would be available for experimentation for this application as well.

c. Document and image facilities. Images of documents, text, graphics, etc. can be economically transmitted over a cable television system on a time-shared basis to many simultaneous users using digitally addressed single images in video format. The resolution requirements of full text and graphics derived from printed or microform materials, however, requires much more resolution than can be obtained with the standard 525 line NTSC line scan format presently used in cable TV systems. Since each image is transmitted as a still frame addressed to a particular viewer, however, a higher resolution image can be provided within the standard 6 MHz TV channel bandwidth by using a longer time for image transmission than the time ordinarily allotted to a single frame. This requires that each user in effect be provided with a high resolution image memory (frame-grabber) for storage during the time that the image is being viewed.

In order to investigate remote viewing of document images, a high resolution format employing 1229 scan lines and 30 MHz video bandwidth has been chosen. This represents a compromise between obtaining

the highest feasible resolution and using commercially available components at reasonable cost. This more than doubles both the horizontal and vertical resolution as compared to the standard NTSC 525 line picture and has been found by others to be adequate for most text. The video signal for such a high resolution image can be sent to the user over the standard TV 6 MHz channel (with 4.2 MHz video modulation bandwidth) by using slow transmission, requiring approximately 0.24 seconds per image. Further resolution improvement by about 10 percent can be achieved by sending a single continuous frame without interlace, saving the time that would otherwise be devoted to the second vertical synchronization interval of the standard NTSC 2:1 vertical interlace. The equipment budget of this grant did not permit acquisition of a slow-scan high-resolution television camera for document viewing, so that the high resolution images will be demonstrated by computer text generation.

Slow-scan non-interlace TV image transmission requires either the use of scan conversion or long-persistence pseudo-random scan at the viewer terminal, if objectional flicker is to be avoided. Since image storage at the receiving viewer end of the cable system is required in any event for time-shared single-image addressed transmission to be used, scan conversion can be provided without additional equipment requirements in the user frame-grabber. This capability has been provided by acquisition of the Hughes model 639-VHR high resolution scan converter which is equipped for slow-scan 1229 line writing and normal 1229 line 30 frames per second, 30 MHz bandwidth reading characteristics. A Ball Brothers high resolution model BH television monitor provides a capability for viewing either the high resolution 1229 line scan output of the Hughes scan converter or standard 525 line images for comparative purposes.

With this equipment a number of experiments related to time-shared use of a CATV channel for information access and educational use can be investigated and explored. The equipment so acquired is also compatible with future expansion of information transmission capability in related projects.

3. Test and Video Monitor Equipment

Head end test facilities include Ball Brothers model TE9RO video and Mark 21 waveform monitors for monochrome video use as well as a Unimedia UMT 1203 Receiver/Monitor (actually a modified 12 inch Sony Trinitron color receiver) for color display. These equipments are shown in the right rack of Fig. 8 and may be connected via the patch panel or external cabling to other head end and remote video image sources. In addition, a Tektronix Model 465 test oscilloscope (equipped for vertical and horizontal television scan synchronization) is available for general test use.

4. Interconnection and Transmission Facilities

The head end facility shown in the block diagram of Fig. 7 is arranged to permit flexible interconnection and rearrangement of the various image generation facilities in order to provide a variety of test bed situations for remote student interaction.

a. Video transmission to remote students. To investigate and demonstrate system use for remote student interaction, several cable channel television modulators (CATEL Model TM2300A) have been set up to accept the images in baseband video format for transmission over the cable system on TV channels 3, 4, 5, and 6. These channels were chosen

because they allow evaluation of the nature and seriousness of interference due to operation over adjacent channels and operation on cable channels in which there is the possibility of interference due to strong over-the-air broadcast in the local area (channels 4 and 5 in the San Francisco area). In addition, operation on channel 6 (for which there is no adjacent upper channel) will allow investigation and demonstration of high resolution transmission by using a wider CATV channel bandwidth; the channel 6 modulator has been modified to permit up to 8 MHz of video modulation bandwidth (double the normal 4.2 MHz NTSC video bandwidth) in order to allow investigation and demonstration of high resolution monochrome image transmission. The four CATV modulators are located in the upper portion of the right equipment rack as shown in Fig. 8.

For situations where direct baseband video cable connection can be made to the remote student locations, no R-F modulation is required. Model 901 Video Distribution Amplifier provides several outputs for such local or simulated remote situations; it is located in the Grass Valley Co. equipment tray immediately below the video patch panel in the lower center of the right equipment rack shown in Fig. 8.

b. Video patch panel. Shown in the photograph of Fig. 8 is the small video patch panel located in the center of the right equipment rack. This panel was locally constructed to provide interconnection between the RAMTEK outputs to the CBS colorizer, monochrome and color image video signals and the various CATV modulators, and video test and monitoring equipment. Several spare jacks allow introduction of other equipment as needed for specific test bed configurations.

B. Remote Student Facilities

Our objective in including remote student facilities in the system is to provide interactive student capabilities ranging in complexity from a simple TV receiver with single digit response to a terminal which can receive individually addressed images and have full alphanumeric keyboard response. To minimize costs the remote facilities use standard commercially-available low-cost equipment as much as possible and should be compatible with time-shared use of conventional cable television systems.

The configuration of the remote facilities is shown in the block diagram of Fig. 12. Equipment has been acquired to set up three such remote stations, which is a sufficient number to investigate and demonstrate time-shared cable TV utilization, although the head-end computer and transmission equipment could accommodate more such facilities at a later date. The television receivers are conventional; two twelve inch Trinitron color receivers provide demonstration of the color image capability, and the Hitachi Memory-vision television receiver provides a third monochrome unit. A fourth Sony CVM 110UA nine-inch monochrome receiver/monitor is available from a related former NSF grant. The same frame-grabbing equipment described for head-end experiments is also available for remote student use experimentation: the Hughes 639-VHR silicon storage tube scan converter, the single-field videodisc in the Hitachi Memoryvision TV receiver, and the Tektronix 4501 Scan Converter. Three Collimation DL50E alphanumeric keyboards and three ComData 150A-2-12 Acoustic Couplers (with built-in serializers) provide student input response capability.

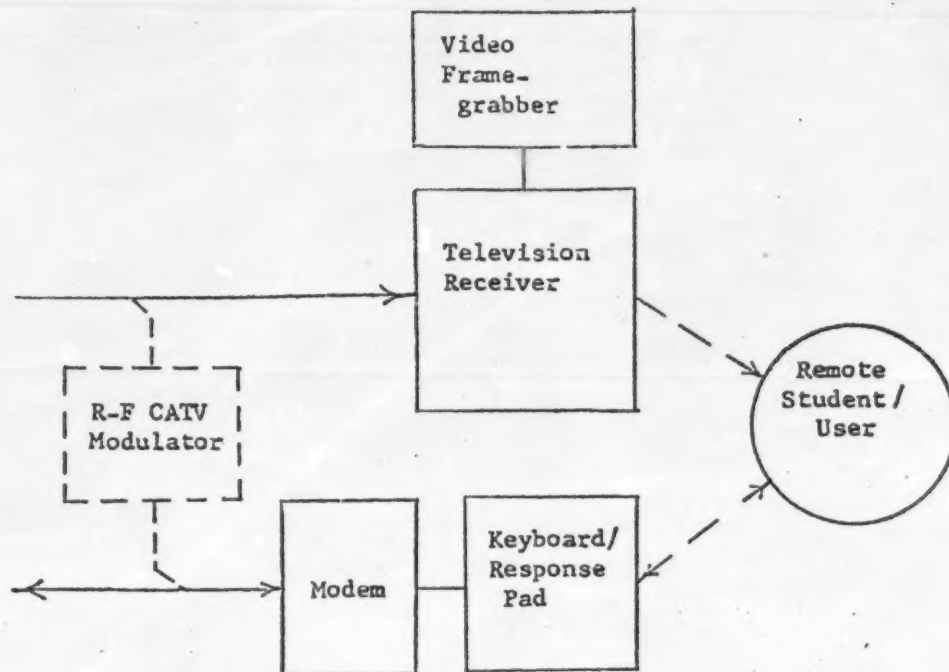


Fig. 12. Student equipment configuration block diagram.

With this equipment a variety of experimental configurations can be demonstrated and evaluated. The remote student facility can range from that of a simple television receiver receiving broadcast programming and using a touch-tone telephone for single-digit response to the most complex situation where the student receives an individually-addressed image which his storage displays hold for his use while the time-shared channel is being used to send similarly addressed images to other students, and with full alphanumeric interaction between the student and (via the head end computer) a variety of major computer resources. The TICCIT system using head-end frame storage and simple user receivers addressed over individual cables can be demonstrated and evaluated in comparison with other approaches using frame-grabbers at the user terminal with a time-shared common cable channel. Computer services such as text editing, information retrieval from library bibliographic services and other public files, and varying degrees of computer assisted instruction are all within the capabilities of the system. In the absence of an operating two-way cable system, simulation with a direct cable will be necessary, with conventional telephone communication use for response from the remote student to the head end computer. At a later time R-F modulators and demodulators can be added for upstream data response over the cable system.

C. Experimental Configurations

The purpose of the effort under this grant has been to assemble a testbed for innovative educational TV experiments with as much flexibility as possible to allow for a wide variety of experimental configurations. To a large degree, a change in experimental configuration can be accomplished by modification of the software of the control computer, with only

minor hardware modifications and additions necessary to accommodate new educational situations. Without any attempt to be exhaustive, we can list some of the possible educational applications for which the test bed can be used:

1. Compilation and display of simple remote student responses to a question posed to all students viewing a common program.
2. Compilation and display of student responses to individually-addressed queries under computer control.
3. Duplication of the TICCIT type of cable TV system with centrally-located digital frame storage, both monochrome and color.
4. Time-shared transmission of individually addressed images over a cable TV system to remote students.
5. Exploration of sequential still-frame television transmission as a means of expanding television channel capacity.
6. Exploration and development of computer software for interactive educational systems to permit access to a variety of computer services.
7. Access via a cable TV system to computer assisted instruction from large computer systems.
8. Access via a cable TV system to text editing and information retrieval services provided by large computer centers both locally and over the ARPA computer network.
9. Investigation of the effect of display resolution variation on educational effectiveness of television.
10. Investigation of the effectiveness of the use of color graphics and text for television instruction.

11. Investigation of slow-scan addressed cable transmission of very high resolution images (such as might be derived from documents or microforms).
12. Comparative evaluation of several frame-grabbing technologies as to cost and effectiveness.
13. Use of two-way cable transmission as applied to live classroom environments.
14. Use of computer-generated vector graphics for educational applications (both color and monochrome).
15. Augmentation of live classroom instruction by computer-generated or mediated video images.
16. Polling of remote students via a common cable channel while displaying live classroom-generated educational programming.
17. Multiple access to stored video programming, such as by using videotapes or videocassettes.

As the technology and utilization of educational applications and operational cable TV systems progress, we will be in a position to anticipate, simulate, and evaluate these and other new situations.

IV. CONCLUSIONS

The Interactive Television Classroom and the Individualized Instruction System are both in operation at Stanford and available to faculty and students who may wish to conduct experiments with them. No experiments, beyond those of checking out the systems and checking their technical performance have yet been performed, but both systems have been checked out, and a wide range of experiments are potentially feasible with each system.

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APPENDIX

Hardware for the Individualized Instruction System:

NOVA 2/10 Computer System	Data General	\$ 25,624.22
GX-100A Video Generator	RAMTEK	18,232.00
Colorizer Keyer	CBS Labs	1,914.85
Video Modulators	CATEL	4,014.33
Sync Generators	Grass Valley Group	2,744.08
Monitor Video Analyzer	Sierra Scientific	2,374.40
Color Receivers/Monitors	Telemation	1,229.60
Keyboards	Collimation	541.53
Acoustic Couplers	ComData	469.37
Memory Vision TV	Hitachi	452.55
CRT Terminal	Omron	2,604.72
629 VHR Scan Converter	Hughes	6,974.83
465 Oscilloscope	Tektronix	2,184.47
		<u>\$ 69,360.95</u>

Hardware for the Interactive Television Classroom System:

Videocassette Recorders and Cassettes Sony V01600	\$ 3,730.21
Sheridan Vote Counter and Display Unit	2,882.42
Switches and Installation (72 switches)	3,575.23
Display Controller for Histogram Display	9,262.37
Scan Converter Tektronix 4501	3,131.73
Switch Fader Dynair VS-152A	2,098.67
Front Camera and Installation GPL 1000	3,877.28
Zoom Lens and Control Canon V10	1,571.14
	<u>\$ 30,129.05</u>
Total	<u>\$ 99,490.00</u>